

The death of Mr. Samuel Powel was announced as having taken place at Newport, R. I., on March 5, 1885, in the sixty-seventh year of his age. On motion, the President was authorized at his discretion to appoint a member to prepare an obituary notice of the deceased.

The Committee on the Michaux Legacy was, on motion, reconstructed by the Society as follows: Thomas Meehan, Frederick Fráley, J. Sergeant Price, Aubrey H. Smith, and William M. Tilghman.

Nomination No. 1049 and new nominations Nos. 1050, 1051, 1052 and 1053 were read.

The rough minutes were read and the Society was adjourned by the President.

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*The Recent Danish Explorations in Greenland and their Significance as to Arctic Science in General. By H. Rink.*

*(Read before the American Philosophical Society, March 20, 1885.)*

No country appears to be better qualified to throw light on the problems of polar geography in general than Greenland. Unto its southern point, though reaching the latitude of Southern Norway, it thoroughly maintains an arctic nature. Its northern extremity has not as yet been explored; here it disappears in regions which hitherto have braved the efforts of the boldest discoverers. This extent from south to north offers a peculiarly favorable opportunity for establishing meteorological stations and for observing how organic life on the terra firma gradually succumbs to the severity of the climate. Here also human inhabitants in their struggle for existence have advanced further towards the pole, the utmost limit of their abodes not being as yet pointed out with certainty. Moreover the mountains of the Greenland coast contain fossil remains important for illustrating the conditions of the Arctic regions during an earlier geological epoch. Its interior can be considered as not yet visited by travelers, but nevertheless we know about it that in its central regions those masses of snow accumulate which, converted into ice as floating icebergs, are spread over the north western Atlantic, stragglers even reaching the latitude of Spain. Upon the northern hemisphere Greenland is the only country that provides the ocean with these enormous fragments, and it is the unbroken continental character of its interior part which enables it to afford the

quantity of snow necessary for producing them. No wonder therefore that modern polar expeditions have considered the exploration of the northernmost part of Greenland one of their chief objects. An expedition has lately concluded which tried to advance in this direction; what these travelers have performed will certainly for ages not be surpassed. The frightful sufferings which they endured, their martyrdom in the service of science, give evidence of the desolate condition, the terrible climate of the coasts they have discovered. In this way the exploration of that part of Greenland can be considered as concluded for the present, and it might perhaps be of some interest to see what has been performed during the latest years with regard to physico-geographical investigation of what we might call Southern Greenland. The fact is, that since 1876 the Danish government has constituted a more *systematic survey of the Danish districts* conformably to a plan proposed by Professor of Mineralogy, P. Johnstrup, namely by sending small parties of travelers with the trading ships. While in Greenland they had to depend on the means of conveyance existing there. Besides surveying and drawing maps, their aims were chiefly geology and mineralogy, occasionally other branches of natural history, and archæology.

If we supposed that Greenland did not extend further towards the north than to the extreme point discovered by the Greeley expedition, its circumference according to a line drawn through the projecting points, omitting the indentations or inlets, might be calculated at 3600 miles, of which the Danish districts make 1000 miles. Of these the expeditions in question have surveyed 670 miles, or an area of 28,000 square miles of coast land including the branches of the sea intersecting it, the fjords and sounds. In Greenland these inlets represent the only highways; where they end, the vast glacier that covers the whole interior begins, and this has only exceptionally been ascended by travelers. Of course these journeys have not been exempt from the troubles and dangers connected with all sorts of Arctic traveling, and required both courage and perseverance, but on the other hand it is a matter of course, that the vicinity of our trading-stations on the coast offered the expeditions a support that enabled them to give more detailed information about the localities visited, than was possible in most cases to the polar expeditions in the far more desolate regions where they wintered or passed by.

The travelers who in different parties have performed these investigations to the summer of 1883 included, have been: Geologist K. J. V. Steenstrup (eight summers and two winters); Lieutenants of the Navy G. Holm (four summers), R. Hammer (three summers and one winter), and A. D. Jensen (three summers); Geologists A. Kornerup (three summers) and Sylow (two summers); Painter Groth (two summers); Supernumerary Officer Larsen; Lieutenant of the Navy Garde; Geologists Knutsen (Norwegian) and Petersen; Botanist Eberlin (all of whom one summer). The traveling parties of 1884 will be briefly mentioned at the close.

THE GREENLAND INLAND-ICE AND THE EUROPEAN GLACIAL EPOCH.—Geologists have for many years been puzzled with the fact that the lowlands extending to the south of the Baltic are strewn with stones which could have no other origin than from the rocks of Sweden and Norway. As from time to time more attention was drawn to these mysterious blocks, they were discovered in a south-western and south-eastern direction, a boundary line drawn from the Rhine in Holland, through Hamburg, Erfurth, Lublin and Kiem in the heart of Russia. At the same time another curious phenomenon was met with in connection with the erratic blocks. Where occasionally the ground was rocky and did not surpass a certain height above the sea, the surface appeared polished and marked by peculiar streaks in a direction pointing more or less towards the home of the erratics. This fact suggested the idea, that the transportation of the blocks could have been occasioned by ice, in a similar way as when glaciers are seen sliding down the mountain slopes, hollowing out the ground and carrying stones along with them which afterwards will be seen covering the ground when a part of the glacier is melted. It is a matter of course, that in adopting this hypothesis we have to suppose an arctic climate to have ruled over these tracts of Europe above alluded to. But even if this be granted, it is obvious that many objections still might be raised. Above all we have to take into consideration the area indicated by the erratic blocks, and to answer the question whether in the present period any ice formation exists that only approximatively corresponds to the magnitude of the glacier of the European glacial epoch. The extent of the surface it has covered is already mentioned; as regards its thickness, the traces left by it on mountain heights have led to the assumption that the ground where now Berlin is situated has been covered with 1000, the low valleys in Norway with upwards of 3000 feet of ice. The said question, however, we are able to answer in the affirmative by referring to Greenland. The recent explorations have now shown, by direct survey, that the margin of what we already have mentioned as the inland ice forms an unbroken line from south to north without any thoroughfare whatever. This certainly only accounts for 1000 miles of the supposed circumference of Greenland, but there is sufficient reason to suppose that the remaining 2600 miles on an average are similar. According to this assumption the area of the inland-ice can be calculated at 360,000 square miles at the least, perhaps we may say 400,000 square miles. It must only be added that very likely mountain chains may be found in the interior rearing their tops above the general ice covering, and consequently these summits are included.

THE INLAND-ICE CORRESPONDING TO AN INUNDATION.—I mentioned that the traces which the glacial epoch has left are limited to a certain height above the sea. This naturally conveys the idea of an inundation, and also from this point of view the present great glacier of Greenland offers the most striking similarity to the supposed ice-formation of remote

ages. When looked over from heights of the outer land, and as far as we know from travelers who have wandered over it, only the marginal part shows irregularities; towards the interior the surface grows more and more level and passes into a plain very slightly rising in the same direction. Here and there, a few mountain tops are seen emerging from the uniform surface. These remains of the submerged land now look like islands in a frozen ocean; they are called by the natives: "Nunataks." Upon these Nunataks, if they have a sufficient extent, snow certainly may likewise accumulate so as to form glaciers. But these patches of snow and ice serve to show the difference between ordinary highland-glaciers and the ice crust that encompasses the foot of the same mountains. Finally to prevent misapprehensions I must add, that in instituting a comparison I have only tried to indicate a similarity, not to identify the surface of the glacier with that of a frozen sea. It must be remembered that in the former the fissures are of a wholly different nature. The following pages will show to what disappointments a traveler would be submitted who ascended the inland ice hoping to find an inundated country upon which the water was covered, like a lake, with solid ice.

MOVEMENT OF THE INLAND-ICE.—We have now considered how the great glacier is able to represent the glacial epoch approximatively as regards its extent, and the nature of its surface. But the most important question still remains, how can the transportation of the boulders be explained? An Alpine glacier which carries stones down into the valley, piling them up as moraines, does not account for the probability of the *transportation of similar masses from Norway to Germany*, even if a sheet of ice from 1000 to 2000 feet thick had covered the way they had to pass. Here again we take recourse to Greenland, asking whether the inland-ice is liable to movements that might correspond to the power required for carrying such boulders? To this question an affirmative answer can be given. Recent investigations show that the great glacier is in continual movement from the interior towards the sea, but that this action is concentrated to some particular points in an extraordinary degree. These points are the so-called *ice-fjords* from which the icebergs issue to the sea. The quantity of these fragments corresponds to the velocity with which the margin of the glacier is pushed on towards the sea. As regards the intermediate spaces between the ice-fjords, the movement is so slight, that the thawing action of the summer warmth balances it, and is able to keep the margin within certain limits.

LIEUTENANT JENSEN'S EXCURSION OVER THE INLAND-ICE IN 1878.—For this excursion a locality was decided upon, in which the outer margin of the glacier had been annually seen by travelers who occasionally passed by during the lapse of more than a hundred years without any conspicuous change of its appearance having been observed. That it was frequently noted was a natural consequence of its situation, as the

icewall here projects almost to the open sea, from which it is separated only by a narrow sandy and marshy plain. It therefore faces the sea in its full height and for a length of about 16 miles, and can be seen from ships at a remote distance. This desolate spot is situated N.  $62\frac{1}{2}^{\circ}$  N. lat., and is well known under the name of the "Iceblink." Here Lieutenant Jensen ascended the glacier, followed by Kornerup, Groth and a Greenlander. They had their luggage loaded on small sledges to be dragged by the travelers themselves. The locality was extraordinarily favorable for observing the movements of the ice on account of the unusual number of Nunataks which here are seen. They form a sort of bulwark or palisade against the ice stream from the interior, the direction and force of which are visible in the disturbances caused in the fragile mass by striking against these hindrances. But at the same time the road across it is rendered dangerous and troublesome in a degree hardly to be imagined by people who never tried to ascend a glacier.

On a large scale, says Jensen in his report, the surface of the ice was undulating, sometimes rising by terraces and not so level as it appears from a distance. Where the gradient increased, the unevenness was enlarged too, the clefts varying from a few feet to upwards of a hundred in breadth. The length was sometimes many hundred feet but generally they were shorter. In many places they were so frequent that the walls were narrower than the fissures. Steep hummocks of ice were still more toilsome, and the tortuosities of the road prohibited using the rope which for security the travelers had stretched from one to another. In places the sledges had to be carried along on the top of the steep and narrow ridges between the gulfs. As soon as a sledge happened to slip sideways, the one that dragged it had instantly to prostrate himself lest he should be drawn into the abyss. When a cleft could be passed, one of the party had to jump over first, while the other remained behind with the sledge, and then both united their efforts to a sudden pull and push. Sometimes the sledge would fall into the crevice and be squeezed between its narrow walls, or would proceed with too much speed and slip into the next fissure. In other places where the slope was less considerable, the fissures were regularly parallel, very long and broad, but with longer intervals. A glance into these gulfs offered the most splendid view of an azure-blue, passing into the darkness of the narrow deep, in many cases perhaps a thousand feet beneath the surface. Sometimes there were no depths at all, and then the water-courses for want of sufficient outlets formed small brooks or lakes very troublesome to the wanderers. The surface was studded with needles of ice, cutting the footgear as well as the hands.

When they had reached a height of 2000 feet above the sea a deep layer of snow commenced covering the ice. This caused more labor in dragging the sledges and greater danger by concealing the abysses.

On the seventh day snow-blindness began to make its appearance. Finally, on the eleventh day, the 24th of July, they reached their goal, the foot of the Nunatak, from the top of which an extensive view further

into the interior could be obtained. About forty miles in a straight line had been passed over, but what miles! No wonder that the explorers were brought to a state of utter exhaustion. As soon as they had arrived a strong gale arose, accompanied by a copious fall of snow and kept them imprisoned in their miserable hut for seven days. The provisions had not been calculated for such a sojourn; the daily allowance therefore now had to be restricted to three quarters of a pound of food. Several times they tried to ascend the top of the hill, but in vain, on account of the terrible snowstorm, until finally on the eighth day they were released. When the weather cleared a grand and peculiar scenery lay unfolded to their sight. The mountain top was 5000 feet above the sea, while their tent at the foot of it was at a height of 4000 feet. To the east a snow-white plain was seen rising very gently and with no interruption whatever into the distant horizon. But to the south in their immediate vicinity several other Nunataks emerged, raising their summits boldly over the icy desert, and here *the true origin of the ice over which they had passed was at once plainly visible*. Though apparently resting it could not have been formed on the spot, but *was brought thither from the interior of the continent*. The Nunataks had been an obstacle to their movement, and the traces of the enormous power against which they had to oppose their walls were manifested in the disturbances they had caused. On the east side, facing the interior, the ice was broken and piled up several hundred feet against the rocks like the breakers of an ocean, while to the south, and north and between the Nunataks it poured down like frozen waterfalls to be embodied in and leveled with the crust over which the travelers had passed.

The rocky hill just spoken of was not wholly destitute of organic life. In the moist and sheltered fissures a pretty large number of plants had taken root, some of them with pretty flowers, such as *Cerastium*, *Campanula*, *Potentilla*, *Ranunculus*, and on the very top, *Papaver nudicaulis*. The travelers even gathered leaves of sorrel (*Oxyria digyna*) as a contribution to their scanty store of provisions. Of animals, a small bird and some spiders were seen, the latter proving the existence of other insects.

Maps have been prepared, illustrating the movements of the ice by indicating how the huge, solid and fragile mass assumes the character of a fluid substance. It is stopped by the Nunataks, but accelerates its course when pressed between them. According to the maps the whole surveyed area of the inland-ice in this place can be calculated at 450 square miles, of which about 120 were less than 2000 feet above the sea. Considering that the latter part as early as the 20th of July was bare of snow and exposed by melting, it will not appear impossible, that during the lapse of ages the heat of the sun has counterbalanced the supply of ice from the interior.

EXPLORATION OF THE ICE-FJORDS.—We have now to consider the more violent actions of the inland-ice caused by the concentration of its movements at certain points of the coast. Some have endeavored to classify

the ice-fjords according to their productiveness of icebergs or to the velocity with which the inland-ice is pushed into these inlets. We have five ice-fjords of the first, four of the second, and eight of the third (least productive) class. The Norwegian geologist Helland was the first who (in 1875) applied direct measurements to the actions of the ice here in question. Hammer and Steenstrup have completed these investigations as regards three first and one second rate fjords. They have proved that the branches of the inland-ice which the sea receives in these places are *pushed on incessantly at the rate of thirty to fifty feet per diem*, this movement being not at all influenced by the seasons. But the velocity thus found first acquires its whole significance by considering the quantity of matter to which it refers. The breadth of the glaciers which extend into the sea is of course variable, depending on the distance between the rocks which border them. In the large ice-fjords of Jakobshavn the glacier which yields the bergs was 4500 meters broad. The thickness can be estimated at a thousand feet. *The bulk of ice annually forced into the sea*, would, if taken on shore and resting on dry ground, make *a mountain two miles long, two miles broad and 1000 feet high*. Sliding over the bottom of the sea it maintains its coherent state until the water is sufficiently deep to lift it, when it breaks and is converted into floating bergs.

Lieutenant Hammer passed the winter from 1879 to 1880 at Jakobshavn for the purpose of surveying the fjord and watching the movements of the ice. He visited the station again in 1883 and has written an excellent monograph on this remarkable locality. By the striking results of his and Steenstrup's investigations, in connection with Helland's and still earlier observations as far back as 1851, we now have not only a trustworthy explanation of the origin of icebergs, but also of the removal of boulders hundreds of miles by the action of ice. A simple calculation will show that while large glaciers in other parts of the world are nourished by the snow falling upon a surface of perhaps twenty to thirty square miles, a first-rate ice-fjord will require a tributary basin upwards of a thousand times as large. For this reason the ice formed in the central regions of Greenland has to travel to the ice-fjords, and sliding over an uneven ground with its enormous weight it cannot avoid breaking asunder protruding rocks and carrying the fragments imbedded in its mass.

CAN IT BE EXPECTED THAT GREENLAND ONCE WILL BE CROSSED FROM WEST TO EAST OR VICE VERSA?—I am convinced that this will be accomplished. The problem seems not to present difficulties equal to such as have been encountered by expeditions in the northernmost parts of Greenland. If the chief object is to penetrate as far as possible into the interior, a starting point has to be selected where, if possible, no Nunataks could be observed from the outer land. Nordenskjöld has been the pioneer in this as well as other branches of arctic research. The renowned explorer has shown, on his voyages to Greenland in 1870 and 1883, how much can be performed by a carefully planned use of an Arctic summer. His excur-

sion over the inland-ice in 1870 disclosed regions of a nature never before observed, and in 1883 he passed far beyond the points reached by others. He took his starting point in  $68^{\circ}$  N. latitude. The first forty kilometers offered a very uneven ice, almost without snow and full of water-holes, ending in a height of about 1100 meters above the sea. For the next twenty two kilometers the ice was covered with a deep sheet of watery snow to a height of 1500 meters, and finally the Laplanders who followed him passed 115 kilometers, reaching a height of 2000 meters. The latter part of this road was quite level, but passing over deep snow without water, and only to be passed by means of snowshoes.

CONCLUSIONS WITH REGARD TO THE UNKNOWN REGIONS ABOUT THE POLES.—As far as I know, the existence of icebergs which might be supposed to have their origin from regions not yet discovered, about the North pole, has not been asserted. On the contrary, in the South sea, we not only meet with bergs whose origin must be derived from an unknown home, but whose dimensions by far exceed those of the arctic bergs. The latter may reach the height of between 300 and 400 feet above the level of the sea, but this only refers to edges or points occasionally turned upwards by the movements to which these floating bodies are continually liable. An iceberg tolerably preserved in its original state, with a flat surface, will not measure more than 100 feet on an average. According to the report given by the Challenger expedition the Southern bergs may be rated as nearly the double of this size. At the same time their perpendicular walls offer a structure marked by horizontal streaks which might augur a difference with regard to their formation. The report adds that these bergs undoubtedly are detached pieces of the large antarctic ice-covering, the perpendicular walls of which, measuring 180 feet in height, were seen by James Ross. Moreover, it is inferred from the occurrence and nature of these blocks, that the South pole hardly can be supposed to be surrounded by continuous land of any extent, but most likely by smaller groups of islands. These tracts then, with exception of the high chain of volcanoes discovered by Ross, must be wholly buried under the same continuous sheet of ice. This description appears to suggest the idea, that the bergs originate more or less from the whole circumference of the ice-crust, which, according to the same supposition, must be imagined to be spread over more sea than land.

I can not conceive of such masses of ice having been accumulated without an extensive area contributing to it by concentrating the movements of its ice-covering to certain points of its circumference, and this again *requires a more or less continental character of the land* representing the said area. The chief part of the latter at least must consist of land. If the movement of the ice-covering was more equally distributed to the whole of its circumference, its margin in being pushed into the sea would be liable to break into smaller parts, and thus be gradually wasted before fragments like bergs could be formed and get afloat. At the same time

the absence of ice-bergs on the border of the unknown Arctic regions excludes the probability of any land of considerable extent being found there.

THE COAST REGIONS.—As regards the ordinary geographical survey of the regions bordering the sea, or intersected by its inlets, a few remarks may suffice concerning certain localities hitherto very little known.

In the first place we here have to mention the immediate *environs of the Cape Farewell*. This point was first explored by Lieutenant Holm, who in 1881 determined its situation by observations on the spot. He found it to be  $59^{\circ} 45'$  N. lat. and  $43^{\circ} 53'$  W. long. It constitutes a part of one of the lofty islands which here, separated by narrow sounds, gird the southern part of the mainland. The travelers were struck by its barren appearance even compared to Greenland. Many mountain heights of the southernmost mainland have been ascended; it may be supposed that further inland they reach a height of 10,000 feet. The inlets here, barren as they are, on the whole present picturesque scenery, on account of the contrast between the steep rocks with overhanging glaciers and the verdant spots at their foot.

We will now pass to *another part of the coast, situated between  $67^{\circ}$  and  $68\frac{1}{2}^{\circ}$  N. lat.* Although within the polar circle, the land nevertheless assumes a more pleasant appearance, presenting lower hills which, as a general rule, have no spots covered with perpetual snow and ice. Here the inland-ice recedes, and the space left by it is occupied by the most extensive tracts of lowland in Greenland. These regions have offered the *chief pasturing grounds for reindeer*, and during the summer season the natives from the south and the north formerly had here their rendezvous, pursuing their favorite sport, the reindeer chase. The fjords by which the country is intersected, afforded roads in various directions suitable to the *umiaks* or skin boats, and therefore this whole complex of land and inlets has always been well known to the natives. But they have rarely been visited by foreigners. For this reason Lieutenant Jensen, aided by Kornerup and Hammer, undertook the task of surveying them with the special aim of affording information about their eastern boundaries in front of the inland-ice.

The travelers were surprised at the number of reindeer horns, and of relics from the hunting-parties that lay scattered over an extensive space of ground, giving evidence of the sport that formerly had enlivened these lonely recesses, but of which very little is maintained. The reason of this decline is simply the disappearance of the animals, and their sudden decrease led to the belief in genial valleys in the interior of Greenland, to which the animals might have migrated. It may sound strange enough, but I believe that we can derive this hypothesis from some words of a document written 600 years ago, during the time of the old Norse colonies. I do not see in this disappearance of the reindeer anything else but an instance of the similar destruction of various kinds of game in almost every

other part of the globe. The chase gradually increased chiefly on account of the more common use of the rifle. It reached its culminating point in the years 1845 to 1849, when the number of deer killed might be rated at 25,000 annually. We may suppose that during those years one-half of the flesh was abandoned on the rocks, while a great many deers were killed only for the sake of the hide and the tongue.

Our travelers, in order to penetrate as far as possible towards the inland, followed an inlet that represented the most interesting type of a Greenland fjord. It is named Nagsutok (*i. e.*, rich in reindeer horns), measures in a somewhat curved line eighty miles in length and forms an almost regular channel two miles broad and from 1000 to 1500 feet deep. At the head of it no inland ice was met with, but a brook or river whose muddy water proved its origin from glacier ice. The country thereabout had a very attractive appearance. The slopes of the mountain sides and the lowland in front of them were clad in luxuriant green. A brook pouring down from the highland and winding through the plains was bordered by a thicket of willows measuring the height of a man, and showing stems of an arm's thickness. Having followed the river first by boat, and afterwards on foot about twenty miles, they were suddenly arrested by the inland-ice that reared its walls above the pleasant valley. The surface of the ice rose somewhat abruptly so as to surpass at a short distance the height of all the land in front of it. A considerable brook issued from the foot of the ice wall, bursting forth from the depth of a cave fifty feet high and broad, the sides of its interior being beautifully tinted with blue.

Finally *between the two northernmost stations, Umanak and Upernivik*, or from  $71\frac{1}{2}$  to  $72\frac{1}{2}$ ° N. lat. a peninsula projects, measuring about 1800 square miles. It presents the longest wholly uninhabited part of the coast-line, and was therefore like the former tract but imperfectly known. Two fjords running behind it from the south and from the north have been made use of by the natives as roads to meet from both sides during the hunting season. But during the present generation nobody was known to have passed the seaward coast of the peninsula in summer, either by kayak or by boat. However, in the month of February, when the sea is covered with solid ice, this way is passed with sledges, which regularly once a year, by conveying a mail, maintain a scanty intercourse between those remote settlements. Meeting now and then an ice bear is the only amusement which the postilions have to relieve the monotony of this wearisome passage. In 1879, Steenstrup, in order to survey the unknown tracts of the peninsula, resolved to try this road in summer time. The shore for many miles presented steep rocks without landing places and girt by numerous icebergs which frequently capsized and broke asunder threatening the passers-by with destruction. Furthermore, a dense fog often prevented their looking out for landing places. Notwithstanding these inconveniences Steenstrup found a party of natives willing to undertake the task, and he speaks in high terms about the carefulness, the courage and assiduity, with which they performed it even during a severe sickness that

happened to attack them. He succeeded in completing his circuit of the peninsula with its inlets, and in filling one of the principal blanks of our Greenland map.

THE ANCIENT GLACIAL EPOCH OF GREENLAND.—Largely provided as it is with ice-formations, Greenland, strange to say, has also a past ice period to boast of. The recent explorations have proved that what we have spoken of as the coastland free from ice was formerly covered with it like the inland, this ice covering reached, in the immediate vicinity of the present inland-ice, a height of 3000 to 4000 feet, and further to the seaward between 2000 and 3000 feet. All the usual traces of ancient ice-streams, the erratic blocks and the ground rocks, are the same here as in Northern Europe. These facts seem to corroborate the glacial theory as a whole. But I cannot agree with the supposition, that merely a change of climate, a rise of the annual mean temperature, should have caused the ice to recede in such a remarkable degree. The ice-fjords bear sufficient evidence of the large surplus of ice still produced by the interior. Should it happen that the bottom of the sea in front of them was raised so as to hinder the icebergs from going adrift and being dispersed, the fjords as well as the adjoining outshoots would soon again be leveled with the interior under the same icy covering. The ice-fjords, as we have seen, afford the drainage of the continent, but this at all events requires the existence of valleys or channels which are able to gather and conduct the downpour of snow and rain in a congealed state to the sea, in the same manner as in the ordinary way it is carried off by rivers. But the beds occupied by such ice-streams and concealed under the common surface of the inland-ice of course must be submitted to changes far more considerable than those of river beds. Consequently new outlets may be opened to conduct and discharge the excessive production of ice into the ocean, and this, I believe, in some measure may account for the ice crust having disappeared from tracts formerly buried under it.

ANCIENT VEGETATION OF GREENLAND.—Over an extensive tract of Greenland, mountains are found containing remains of plants which prove that the spot occupied by them in remote ages had *a climate like that of Southern Europe*, and some of them, like that of Madeira. In speaking of ages, we here refer to geological time, counted by many thousands of years, and changes since have taken place on a large scale as regards the configuration and distribution of land and sea, but it can be considered as a matter of fact that the area here in question has been occupied by tracts of land or perhaps groups of islands covered with the vegetation of a warm latitude. Its remains occurring in layers of sandstone and shale, accompanied by beds of coal, have attracted peculiar attention by the investigations of Professor Heer in Zürich, to whom the collections were sent in order to be determined. In 1866, Heer explained his reasons for concluding that the fossils laid before him belonged to plants that had grown on the very spot where the remains were found, or in its immediate vicinity

He alluded to one of these localities as bearing evidence of *a whole forest having been buried there*. Numbers of trunks and branches were imbedded in the sandstone formed out of the sand that once enveloped them. Reddish-brown ferruginous parts of the sandstone beds are filled with amazing quantities of leaves. Generally their substance is preserved, whereas some of them exist only as impressions. A piece of sandstone six inches square contained twenty-six leaves belonging to eleven species. In other pieces the leaves all belonged to the same species. As regards animals only the wing shells of some insects had been found. But fruits and seeds were found in connection with the leaves, all the parts being in such a state of preservation as to exclude the possibility of their having been carried from some distant place. They must have been derived from plants growing in a peaty soil and in the surrounding woods. The Arctic expeditions led to the discovery of similar remains in many places throughout the Polar regions from Banks land in the far west to Spitsbergen. But here again Greenland has offered the most favorable opportunities for exploration, and especially during the latest years afforded materials to throw light upon the other Polar regions with regard to this branch of natural science. The earlier series of discoveries were concluded by the rich collections brought home from Greenland by Nordenskjöld in 1870, and completed by Nauckhoff in 1871. In the "*Flora fossilis arctica*" of Heer, the number of Greenland species was brought up to 316. By Steenstrup's collections in 1878-1880, this number was increased to 613; this result induced Heer to publish a separate work under the name of "*Flora fossilis Grenlandica*." Having received these latest collections from Greenland, Heer wrote that he would be able to describe the remarkable forests that during two geological epochs had covered those regions of the far north. He derives the fossil plants partly from *the tertiary*, partly from *the cretaceous period*, a long interval severing these divisions. The tertiary Flora of Greenland comprises not less than 200 species of trees and bushes. The woods presented twenty-eight coniferous, but far more foliferous trees, such as *poplars, birches, elm, plane-trees, ash, maple, beech, chestnut, a number of oak and walnut, four laurels, three ebony, six magnolias and two fan-palms*. The insects comprised thirteen species, but of Vertebrata not the least trace has been discovered.

Of the cretaceous plants the most important families are: Cycadææ, Araucariæ, Zingiberacææ, Balanophoræ and Sapotacææ. *The Cycadææ and the arboreous ferns* lead to the supposition of a climate like that of Funchal or Madeira, which during the tertiary epoch had passed into that of Southern France.

In 1883, Nordenskjöld was accompanied by the distinguished botanist, Nathurst, who, according to the preliminary report, has paid peculiar attention to the fossil Flora of Greenland, and not only discovered many new species, but also afforded valuable information as regards the number and chronological order of the strata and the question about the soil in which the plants have rooted.

STRATA OF VOLCANIC ORIGIN, NATIVE IRON.—Towards the close of the periods in which the remarkable remains of an ancient vegetation were accumulated, igneous matters must have burst forth from the interior of the earth and covered them to an amazing height and extent. As to their texture, their origin and mineralogical character they are undoubtedly to be classed with lava-streams, although in certain respects distinctly differing from them. These ancient lava-rocks, the trap and basalt, differ from those of present volcanoes by the absence of conical-shaped mountains that might indicate the channels through which the burning streams forced their way to the surface of the earth. In fact there are but few traces to be seen of their connection with the unknown depths whence they originated. We have before us extensive table-lands, between 2000 and 5000 feet high, with walls more or less perpendicular or terrace-shaped, and exhibiting a series of horizontal strata one above each other in a remarkably uniform manner. At the foot of these cliffs the sandstone in which the fossil plants are imbedded generally appear, forming slopes on lower hills, apparently the edges of a more extensive formation that lies concealed under the trap. But as regards the igneous rocks here in question, I shall only mention a discovery recently made concerning one of their most interesting features.

*Native iron* was found in Greenland thirty years ago, in the shape of a few loose pieces on the surface of the earth. In 1870 *enormous blocks were found by Nordenskjöld*, the largest of them being estimated at 46,200 pounds, specimens of which the following year were brought to Europe by a Swedish expedition. Nordenskjöld observed that the basaltic rock in the immediate vicinity of these loose blocks of iron contained lamina of the same metal imbedded in its mass. The first pieces that had been found in Greenland, like native iron on the surface of the earth in other parts of the world, was determined as meteoric iron. The occurrence of iron in situ as a constituent part of the basaltic rock seemed to subvert this theory of a meteoric origin. Nordenskjöld, however, maintained it, stating that the downfall had taken place during the formation of the basalt. A long dispute arose about this question, which now must be considered as ended, *the meteoric origin almost universally having been abandoned* on account of a discovery made by Steenstrup during the last year of his stay in Greenland. It is also well known that John Ross, in 1818, found the Eskimo of Cape York in possession of knives in which they had inserted iron found by themselves in their country. Now Steenstrup, in 1879, on examining old Eskimo graves in the Umanak-fjord discovered in one of them knives just of the same description as those found by Ross, and with them in the same grave pieces of basalt were also discovered, which on being closely examined exhibited grains or nodules of iron like that inserted in the knives. It was the more obvious that the basalt pieces had been intended for such use, as in the same grave stone knives were found in connection with the raw materials of which they were made; quartz, chalcedony and such like. These facts suggested the idea that iron had been more com-

monly used by the Eskimo than could be expected if they had been restricted to pieces of meteoric origin. The next question was whether more localities could be pointed out where the basalt contained metallic iron. Just before leaving Greenland, in 1880, Steenstrup succeeded in solving this problem. On the west side of Disko island, at an abandoned wintering station called Asuk, he found a layer of basalt fifty feet thick filled with grains of iron of various sizes to a length of eighteen millimeters and a breadth of fourteen millimeters; which were the largest of them. Afterwards he found just the same sort of basalt on the west side of the island constituting much larger strata.

It may be added that in a conversation I had with the renowned Norwegian geologist Kjerulf about the questions here discussed, he referred to what has been long taught by him about the supposed increase of the specific gravity of minerals proportionately to the depth below the surface of the earth where they have their origin. He had instituted this comparison in order to find an explanation of the great difference between the earth's crust and its interior as to specific gravity. It has long been supposed from chemical proofs, that basalt contained metallic iron, but the occurrence of this substance in the shape of visible grains had never been ascertained before. For this reason Prof. Kjerulf considered the discovery of the huge iron blocks as still more important in certifying the origin of the iron from the depths of the earth and not from the atmosphere.

THE PRESENT FLORA OF GREENLAND.—In 1857 the known species of of phanerogamous and of higher cryptogamous plants in Greenland amounted to 320. Several collections have since been secured. Prof. J. Lange undertook a revision of the whole material, by which the number of species was increased to 378. His results contradicted several earlier assertions. This flora is not (as suggested by J. D. Hooker), chiefly European; it is about *as much American as European*, chiefly American in the north, European in the south. For this reason the theory of its immigration from Europe can no longer be maintained. It is also incorrect to call this flora poor in comparison with other Arctic countries and to assert that no species exists peculiar to Greenland. Of course the area of the inland-ice has to be deducted with regard to this comparison. Not less than nineteen species are found that are peculiar to Greenland. But Greenland is relatively deficient in annual and biennial plants on account of the difficulty in having the seeds ripened. It should be remembered that the 10° C. isotherm of July passes from the middle of Labrador far south of Cape Farewell to Iceland.

ARCHÆOLOGY.—Greenland in some measure can be called one of the elder colonies, if not one of the oldest. About the year 1000 it was peopled by Scandinavian settlers from Iceland. In 1450 their intercourse with Scandinavia was interrupted, when the country was re-discovered they

had disappeared, and an Eskimo population was met with instead. The present trading stations were founded after 1721. *Ruins of the ancient settlements*, however, were from time to time discovered, partly between 60° and 61°, and partly between 64° and 65° N. latitude, while the interjacent tract had been almost uninhabited. Our recent expeditions have not neglected the opportunity to continue these investigations, especially Lieutenant Holm has examined the remains in the southernmost of the two districts. According to his report 100 different ruins of ancient hamlets have been discovered there, the largest of them containing the remains of thirty buildings. The houses are from twelve to eighteen feet broad. The length is twenty to thirty feet or, when divided by a partition wall, fifty feet. Digging up the interior, burnt wood and iron nails are found on a level with the original floor, indicating a destruction by fire. Some very narrow buildings were evidently stables, the remains of stalls still being visible.

As barren highlands are frequent even in these most favorable portions of Greenland, the settlers were restricted to narrow borders of lowland, chiefly at the head of fjords. In contrast to Greenland scenery in general these spots exhibit a fertile and inviting appearance, especially where such a lowland continues across a peninsula joining a corresponding spot in the next fjord. The number of ruins show that these localities had the greatest attraction to the Scandinavians. Lieutenant Holm has given us a description of such a valley, the middle part of which had scarcely been visited by natives during the latest generations, and with perhaps a single exception, never by Europeans. From the head of the Igaliko-fjord, where the bishop of the ancient colony is supposed to have resided, a valley presenting low hills, plains and lakes runs across the peninsula that separates this fjord from that of Lichtenau (a Moravian station), a distance of eight to twelve miles. In the middle of this isthmus Holm discovered some ruins of considerable extent, but with walls only rising a few feet above the ground and overgrown by tufts of grass and willows. The environs of these stone-heaps, the only monuments that are able to tell about inhabitants whose final fate will forever remain a mystery, are described as very picturesque. Luxuriant copses of willows and low birch border the lakes, a magnificent waterfall is seen rushing over the rocky walls sprinkled with green, and in the background the mountains of the Lichtenau-fjord rear their tops into the air covered with perpetual snow and ice.

As regards *antiquities from the Eskimo period*, Steenstrup has examined a number of graves in the northern districts. Where natural masses of stones were found, the cavities formed by them had generally been preferred as sepulchral rooms, but when these were lacking, the dead used to be buried on the tops of the hills. In "Unknown Island" (latitude 71°) a cemetery was found at a height of 640 feet and only accessible by a steep and narrow path. The graves are built up with walls of stones, flat stones used as a roof. Generally they offer room enough only for the corpse in a bent position, but sometimes the dead are laid at full length. Often two

corpses or even more are in the same chamber. Such a room was once found measuring four feet in length by two feet in breadth, and containing the skulls of thirteen grown-up persons and two children. Several graves were found in which the number of skulls did not correspond to the rest of the skeletons. Still more curious were some graves carefully built but evidently never occupied by any dead. The properties which were considered as belonging to a person even after death were sometimes merely left at the side of the grave, sometimes lodged in separate rooms. In one instance a sepulchral chamber was found containing the weapons and tools of a kayak man, but no skeleton. Had these things perhaps drifted ashore, when their owners had found his resting place on the bottom of the ocean?

**THE EAST COAST OF GREENLAND.**—When compared with the districts we now have treated of, little attention has been paid to the coast east of Cape Farewell. Since 1828, to 1831, when Captain Graah explored the coast from its southernmost point to 65° latitude, this part of Greenland, still inhabited by heathen Eskimos, was not visited by exploring expeditions or by foreigners until 1883. We speak here only of the Danish part of the west coast, omitting the far north beyond 70° latitude. The difficulties arising from the drifting ice are very great, but still they do not account for a curious fact we here meet with. The coast from 65° to 70°, where Greenland approaches nearest to Europe and faces Iceland, has never been visited by foreigners. It is only 150 miles distant from Iceland, whose ancient settlers discovered Greenland, and still the inhabitants of this very part of Greenland have never seen people of other nations than their own. Another consideration has prompted a survey of the east coast. The ancient Norse colonies were divided into "Eastern" and "Western" settlements. When the first ruins of them were discovered, on account of their situation to the west of Cape Farewell, they were naturally supposed to be the remains only of the "Western settlement." Later it was supposed that both divisions were situated on the west side, one a little more to the east than the other.

In 1879, Captain Mourier, of the Danish navy, explored this unknown coast with the schooner *Ingolf* for a distance of about twenty-four miles. He stated that about the latitude of 65° the coast in many cases could be reached and a landing effected. Planning another expedition, it was suggested to proceed in two ways. A landing might be tried to the north of 70°, and then a voyage southward inside the ice barrier might be effected either by ship or by boat. The other way would be to follow the steps of Captain Graah by boat along the coast from Cape Farewell.

According to the latter plan, Lieutenant Holm, in 1883, again went to Greenland, followed by Garde, Knutsen and Eberlin. The first summer being intended only for preparatory arrangements, they departed from the southernmost settlement with four skin boats manned with natives and reached a place called Kassingertok in 61° latitude, where a hut was built

and filled with a depot of provisions for the next year, such as pemmican, meat biscuit, sugar, peas and barley. They then returned to their winter quarters at Nanortalik, on the west coast.

Meanwhile, Nordenskjöld had been engaged also with the east coast problem, and his efforts were crowned with a marvelous success. Having performed his excursion over the inland-ice and had his ship sent on an exploring voyage as far as Cape York, he reached the east coast about the latitude of  $65\frac{1}{2}^{\circ}$  and discovered a harbor where he anchored. Of course his stay could only be for a short duration, but still he is the first explorer who penetrated from the sea to this coast.

EXPEDITIONS OF 1884.—In the spring of this year two expeditions set out for Greenland. The first consisted of Lieutenant Jensen with two scientific companions and was ordered to survey the district between  $65^{\circ}$  and  $67^{\circ}$  latitude. The other was led by Captain of the Navy C. O. E. Normann, an experienced traveler in Greenland, and an authority as regards Arctic questions in general. He commanded the man-of-war schooner *Tylla* ordered to inspect the fishing-banks in front of the trading districts and to continue the survey of the coast in connection with other explorations.

As regards the east coast explorers, a letter has arrived from the leader, dated the 17th of July, according to which they had reached the latitude of about  $62^{\circ}$ , having been as usual much impeded by ice. They hoped to reach a populous place called Angmagsalik, somewhat beyond  $65^{\circ}$  latitude, and to winter there.

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*On the Detection of Adulterations in Oils. By Prof. Oscar C. S. Carter, Central High School, Phila.*

*(Read before the American Philosophical Society, March 20, 1885.)*

The chemical examination of oils is a very important though much neglected study. Important from the fact that the oils which command a high price in the market and are in general demand are frequently adulterated. The temptation to adulterate is great on account of the heavy increase in profit and because the adulterant is often very difficult of detection. The purchaser is always at the mercy of the oil merchant unless the oil be submitted to a chemical examination. "Our former Consul at Naples reported to the State Department that immense quantities of refined cotton seed oils are sent to Italy for the express purpose of sophisticating the